CHOOSING METHODS AND EQUIPMENT FOR LOGGING

by

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FOREWORD

This is the first of a series of papers about the supervisory part of the logging job. It deals with the choice of methods and equipment for logging. Other papers planned for publication will deal with job layout, recruiting and training of workers, purchase of timber, and marketing timber products.

Eventually this information may be combined under one cover. Consequently, your comments, criticisms, and suggestions will be appreciated.

The woodsworkers' part of the logging job has already been covered in the Northeastern Loggers' Handbook, which has been issued by the Station in preliminary review sections during the past 2 years. This handbook is now being prepared for printing as a Department of Agriculture publication.

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A logging job is one of the most difficult types of business to manage efficiently. In practically everything the logger does he is compelled to make a choice between several methods of operation and types of equipment. The conditions under which he works are constantly changing, particularly when he is forced to move fairly often from one timber tract to another. But even on different portions of the same tract conditions can change; the equipment and method of logging may no longer be suitable, and costs may go up out of sight. Many logging operators go broke because they do not recognize such changes and adapt their operations to them. Others are notably successful because they do.

FACTORS TO CONSIDER.

There are several general factors to consider in deciding on methods and equipment. These include the timber stand, the lay of the land, the ownership pattern, the labor available, the equipment you have on hand, and the desires of the property owner.

The timber stand

The volume of timber to be cut is very important. Against it must be charged the fixed costs of the job, including cost of roads, landings, camps, and other facilities. A $5,000 road against 5 million board feet costs $1 a thousand. If only 500 thousand feet is cut, the road costs $10 a thousand.

The kind and quality of timber is important too. Birch, beech, and maple logs averaging 18 inches in diameter weigh about 4 tons per thousand board feet. White pine of the same size weighs only about 2½ tons. This variation in weight makes a big difference in skidding, loading, and hauling costs. Knotty and crooked timber weighs more per thousand board feet and takes up more room than clear straight timber. Nowhere near so much can be skidded per turn, or loaded on a truck. Small logs weigh more per thousand board feet than big ones of the same

species. High-quality material will repay a lot more expense in logging than lower-quality material.

The lay of the land

Special logging methods have to be adopted in rough country. The lay of the land often determines the boundaries of logging chances, and restricts the area that can be tapped by a logging road. Rock cliffs or scattered rocks, streams, lakes, swamps, and brush may also exert a decided influence on logging methods and equipment.

Figure 1.--A 25-horsepower tractor can ground-skid only about 1 ton on an uphill slope.

The presence of a suitable slope is a big help in some respects. A 20-horsepower tractor can ground-skid 3 tons of logs on dirt on a 20-percent downhill slope, and 1-3/4 tons on the level; but on a 20-percent uphill slope it can skid less than 1 ton (fig. 1). Snow and ice roads increase these capacities.

Ownership pattern

In a rough country the pattern of land ownership is often highly important. When such a country is laid out with a system of rectangular

survey, the logger frequently finds a natural logging unit divided among several separate owners, each with different desires and interests. Suppose the owner at the head of the hollow wants his timber logged, but none of the others do? All too frequently it is found that the timber on one owner's property is too small a quantity to justify the necessary access road. On the other hand part of a property offered for cutting may drop over a ridge into a different drainage area; and if that portion is to be cut expensive uphill skidding is necessary.

Wishes of the landowner

With increasing frequency, as more owners of forest lands become interested in forest management, the wishes of the landowner will affect choice of methods and equipment for logging. Selective logging, which involves light and relatively frequent cuts on the same area, will favor the use of highly portable and mobile equipment. Frequently the logger will find the landowner prejudiced against the use of tractor-and-arch combinations or light cable-skidding devices, which are well adapted to this type of logging, because of damage he has seen created by such equipment when it has been carelessly used. As owners become more interested in their properties, and more insistent on protection of young growth and of trees selected to be retained for future growth, logging operators will have to make sure that their men operate the equipment more carefully. This applies as well to the older methods of logging. Careless felling and thoughtless use of horses in skidding have frequently been the cause of as much damage to the future stand as tractors and cable-skidding.

Labor

Often the type of labor available, and its working habits, dictate the logging methods and equipment. Men accustomed to working at a given price for a cord of ricked pulpwood induce an operator to continue stump-cutting when it is generally recognized that yarded wood would be cheaper--and a better conservation practice for the remaining stand. Hardwood buckers are very often loathe to vary their log lengths to get maximum volume and value out of the trees they cut.

Equipment on hand

The small operator, particularly, must often use the equipment he already has instead of getting something else much better adapted to the situation.

With such a variety of factors influencing his choice, it is little wonder that the logging operator is apt to resist changing his methods. Even in cases when he does make a change it is difficult to foresee how the new method will fit in with these conditions; and it may sometimes result in more expensive instead of cheaper logging.

But within practical limitations it is frequently possible for the small operator to size up a given problem realistically, and to make a choice of logging methods or equipment well within his means that will make the difference between success and failure on a given job or portion of a job.

ACCESS ROADS

It is frequently difficult to decide how good and how expensive a road to build into a given timber chance. Road-building costs vary over a wide range depending on difficulty of construction. A single bridge often costs as much to build as a mile of road. Side-hill work, particularly in rock, can be very expensive. Sometimes by going around such obstacles instead of across them the road will be cheaper, although it is longer.

Figure 2.--A tandem-axle truck can haul about 2,000 board feet of logs per load.

The most important factor is the amount of time it will take to bring a thousand board feet out of the woods. A careful appraisal of fixed truck costs, including depreciation and the driver's wages, will show that running cost per hour is a lot more important than running cost per mile. Depreciation on even a light truck equipped for logging can easily amount to 25 cents per hour, and a driver's wages $1.40 per hour. Operating costs when traveling in lower gears on rough woods roads are more realistic on a per-hour than on a mileage basis. Operating a tandem-axle truck (fig. 2)--average load 2,000 board feet--with an hourly operating cost of $2.98, on a rough woods road (fig. 3) at a

speed of 4 miles per hour costs 74 cents a mile. At 9 miles per hour the cost drops to 33 cents and at 19 miles an hour to 16 cents. Round-trip costs are twice as much, if no greater speed can be made on the return. If 500 thousand feet are to be logged, 5 miles in from the hard road, the allowable expenditure for a better road can be worked out as follows:

Type of woods road	Miles per hour	Hourly truck cost	Cost per round-trip mile per M	Cost of 5-mile round trip	Cost of hauling 500 M bd. ft.
Rough	4	$2.98	$.74	$3.70	$1,850
Medium	9	2.98	.33	1.65	825
Good	19	2.98	.16	.80	400

Figure 3.--Trucks can be operated only at slow speeds and in low gears on rough woods roads.

Consequently, if the road could be improved from a 4-mile-per-hour standard to a 9-mile-per-hour standard for $900 it would be good business. Not more than 400 more should be spent, however, to improve the latter road to a 19-mile-per-hour standard.

HAULING vs. SKIDDING

A 25-horsepower tractor equipped with winch and sulky is capable of bringing out 1,000 board feet of tree-length logs per trip It has an hourly operating cost of about $4.60. Suppose the last mile of the above woods truck road was very expensive to build, but a road suitable for tractor use was already there. How much could be spent on this mile of road to eliminate skidding this extra mile? This tractor travels 2.4 miles per hour in second gear on the trip out and 3.2 miles per hour on the return. Consequently, the round trip is made in 0.73 hour and costs $3.36. This delivers a thousand feet of logs a mile nearer the hard road. But a truck can haul a thousand feet of logs a mile over a very low-grade road for 74 cents. Consequently, the difference between the two methods of transportation is $2.62 per thousand board feet or $1,310 for the total job. If the mile of truck road could be built for any less than this, it would be good business.

In any such calculation, particularly on a small job, the practical aspects of the equipment situation have to be kept in mind. If the truck could make an extra trip a day by eliminating that last mile of haul it might change the situation materially. Or if the tractor were just sitting around much of the time, with costs going on but no work accomplished, it would be more desirable to give it the extra job.

DIFFERENT METHODS OF SKIDDING

In deciding whether or not to buy a new piece of equipment, it is necessary to determine under what conditions it will work economically. Take the question of horses vs. tractors in skidding, for example. A little work to gather data will show where one system is more economical than the other. Data from an actual operation showed that a team and driver cost $12 a day; that at an average skidding distance of 200 feet this team brought in an average of 6,250 board feet of logs per day, at 400 feet an average of 4,425 feet of logs, and at 600 feet an average of 3,425 feet of logs.

A 25-horsepower crawler tractor equipped for ground-skidding with driver and choker-setter cost about $3.36 per hour or $26.88 for an 8-hour day. But the tractor made its round trips more quickly, without periods for rest, and brought in a heavier load. Data from a comparable operation showed that such a tractor ground-skidded 11,900 board feet of logs per day on an average 300-foot skid, 10,340 board feet at 500 feet, and 7,680 board feet for an average of 1,000 feet.

From these figures it was possible to work out the cost of skidding per thousand board feet of logs (table 1).

Table 1.--Cost of skidding compared for team and tractor

Team				Tractor			
Skidding distance (feet)	Cost per day	Bd. ft. skidded per day	Cost per M bd.ft.	Skidding distance (feet)	Cost per day	Bd. ft. skidded per day	Cost per M bd.ft.
200	$12	6,250	$1.92				
300				300	$26.88	11,900	$2.26
400	$12	4,425	$2.71				
500				500	$26.88	10,340	$2.60
600	$12	3,425	$3.50				
1,000				1,000	$26.88	7,680	$3.50

It is apparent from these data that the tractor did the cheaper skidding job at the longer distances. For the short skidding distance the costs of horse and tractor skidding were about equal.

From past experience with this type of data we know that the skidding costs tend to follow a curve--increasing by rather regular intervals for each increase in distance. If more nearly comparable data

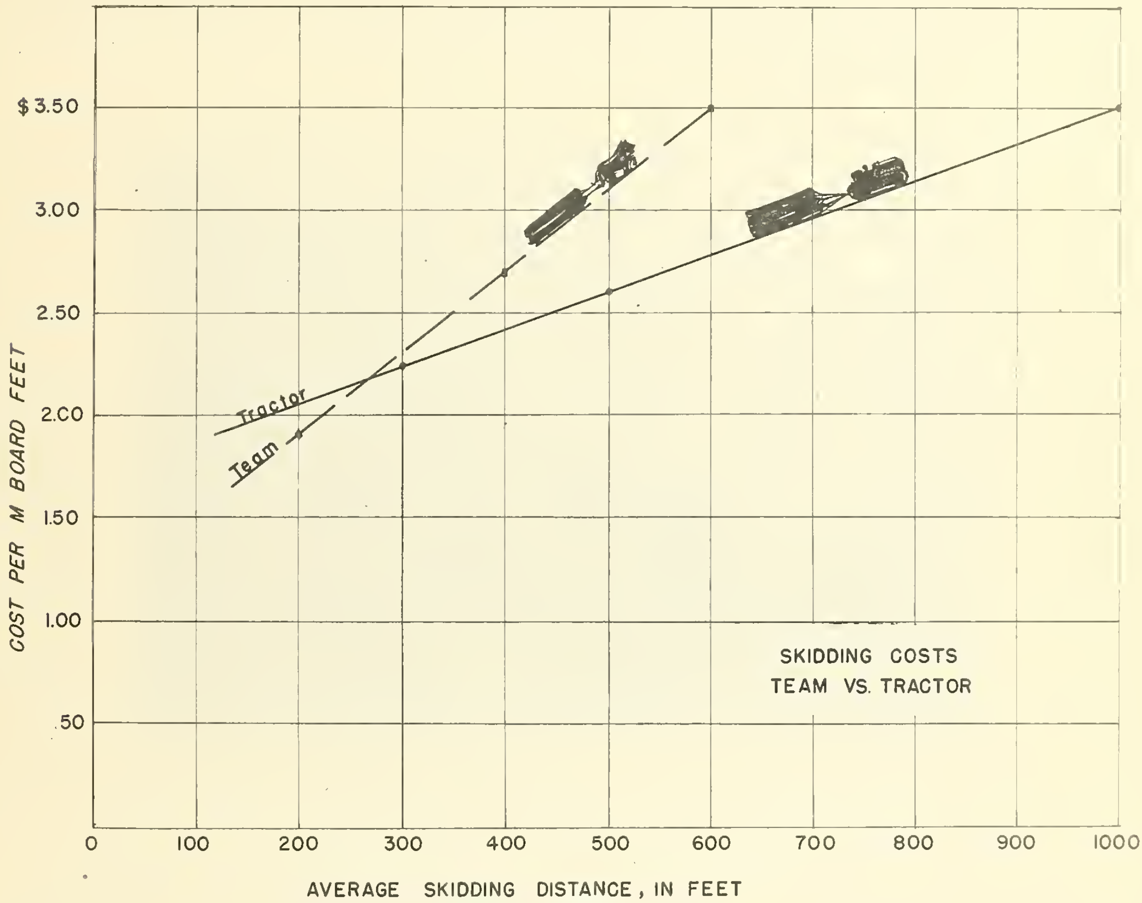

Figure 4.--Comparison of skidding costs per thousand board feet, team and tractor, at various distances.

for the short distances could be obtained, it would be possible to determine this more surely and exactly, but a further comparison can be made with the data at hand by plotting them on a graph (fig. 4).

It would be possible to gather data on other types of skidding devices, if they could be found working in reasonably similar conditions, and enter them on the graph also. It could be expected that the

same tractor, equipped with a winch and sulky (fig. 5) or a scoot, would show a lower skidding cost over the longer distances, say over about 500 feet, because of the still bigger loads it would bring in. This would not, however, be clear gain because of delays in bunching the larger load and in turning around. On the shorter skids the tractor alone might be the more economical.

Here, too, practical problems will come into the picture. If a man has a tractor but no team available, he would certainly use it on

Figure 5.--Tractor equipped with winch and sulky.

the shorter skids. A new lighter and more maneuverable 15-horsepower tractor might prove to be more economical than the team at all distances. On the other hand, the logger might not have enough volume to handle, or enough cutting and loading capacity to provide 10,000 feet a day for the tractor to skid. In such a case it might be better for him to resign himself to the higher costs of horse skidding to avoid having the expensive tractor and perhaps its even more expensive crew sitting around idle much of the time.

METHODS OF LOADING

Problems in deciding on the type of equipment to provide for a given operation can, of course, be much more complicated than those cited above. Take loading, for example. If one is loading by hand

from skidways it is necessary to decide how many to build and at what interval they should be placed (fig. 6). If a large number are built, at relatively close intervals, the initial cost of clearing and building will be increased, but skidding distances may be shortened and skidding costs decreased. The same principles apply to the number and location of roads. A frequent mistake made by loggers when they take on a selective-cutting job is that they build the same number of roads and landings that they used for clear-cutting and other heavy cuts. On the selective-cutting job they may not have enough volume to repay costs. In such cases it is usually better to skid longer distances or to

Figure 6.--Hand loading from skidways.

purchase or construct a loading device that could load from the ground at any point along the road.

Even for jobs on which heavy cuts are made, such loading devices are being purchased because they load so much faster and thus shorten the time when trucks are idle. For scattered timber the loader is frequently mounted on the hauling truck itself (fig. 7). For heavier cuts it may be on a separate truck, and for really heavy concentrations of logs at one place it may be stationary, or mounted on a crawler tractor or on skids. Skidding costs and hauling costs are tightly tied up to loading costs; so the problem of determining the most economical setup for a given set of conditions is a complicated one.

As an example, consider a logging chance composed of five steep hollows on one side of a valley. There seems to be no option but to skid down to a landing at the mouth of each of these hollows. Logging will proceed in each of the hollows simultaneously at the rate of 10,000 board feet a day. Tandem-axle trucks, capable of hauling 2,000 board feet a trip with a standby cost of 4.8 cents per minute, are to be used.

Clearing and building a skidway or brow at the mouth of each of these hollows would cost $1 per thousand feet for the amount of timber to be handled. The truck driver and his helper can load the 2,000 feet

Figure 7.--For scattered timber the loader is frequently mounted on the truck itself.

of logs in about 30 minutes. Rolling logs onto the landing usually would not increase skidding costs. Consequently, the cost of loading from landings is the cost of the landing plus the standby time for the truck (4.8 cents per minute x 15 = 72 cents) or $1.72 per thousand board feet.

The operating cost of a truck-mounted loader would be $5 per hour, but it will cut loading time to 5 minutes a thousand. Consequently, loading costs for this device will be 1/12 of $5 or 42 cents plus truck standby time for 5 minutes or 24 cents, totalling 66 cents per thousand board feet. But in addition, the loader will accumulate some standby

time under this method, [illegible] minutes per thousand board feet for 50 thousand feet per day [illegible] minutes the loader is working. There are 480 minutes in an 8-hour day, so the loader will be idle, or moving from landing to landing, [illegible] minutes each day, or 3.83 hours. At $3 per hour this will cost [illegible] per day, or [illegible] cents per thousand board feet. The total cost of mechanical loading in this case would be 66 cents plus 23 cents or 89 cents per thousand as contrasted with $1.72 per thousand for hand loading.

If the total cut per day were only 10 thousand board feet instead of 50 this standby time would be 430 minutes at $3 per hour, or $21.51. Prorated against 10 thousand feet that would be $2.15 per thousand plus 42 cents, or $2.57 per thousand on the smaller job. Truck standby would add another 24 cents, making the total cost $2.81 per thousand.

Figure 8.--Loader mounted on a separate truck.

The costs for the two methods worked out above are summarized in table 2.

KEEPING COST RECORDS

Examples like those given thus far could be continued indefinitely, but enough have been given to bring out the main principles of deciding, from a cost standpoint, which are the most advantageous and economical methods and equipment [illegible]. Such comparisons are all based, however, on reasonably good cost and production records for various types of machinery and methods of operation. Such records, unfortunately, are kept by very few [illegible].

Table 2.--Comparison of loading costs for skidway and mechanical loader methods

Method of loading	Volume loaded per day	Loading time per M bd.ft.	Truck standby costs		Skidway costs per M bd.ft.	Mechanical loader costs						Total loading cost per M bd.ft.
						Operating		Standby				
			Per hour	Per M bd.ft.		Cost per hour	Cost per M	Total time	Cost per hour	Total cost	Cost per M	
	M bd.ft.	Minutes						Hours				
Rolling from skidways	50	15	$2.88	$0.72	$1	--	--	--	--	--	--	$1.72
	10	15	$2.88	$0.72	$1	--	--	--	--	--	--	$1.72
Mechanical loading crane	50	5	$2.88	$0.24	--	$5	$0.42	3.8	$3	$11.49	$0.23	$0.89
	10	5	$2.88	$0.24	--	$5	$0.42	7.2	$3	$21.51	$2.15	$2.81

Such records do not need to be elaborate, and they do not need to be costly. In most cases they will repay their cost many times over by revealing inefficient pieces of equipment or methods of operation.

Frequently, particularly in tree-length logging with bucking at the roadside, scaling is done at the landing. If the logging superintendent collects some notes as to conditions under which the work is proceeding at each landing, he will soon have a body of information on which reasonably good cost figures can be based. For example, he should know for each of the five landings, in the case cited in the last example above, what skidding equipment was working, the average length of skid, and the conditions under which skidding was done. These data would then be useful in comparing the efficiency of different machines or different operators in the manner of the example given under "Different Methods of Skidding." Frequently the felling crews are paid according to the scale of the timber they cut, identified at the landing by initials keeled on the butt end of each stick. This gives an opportunity for comparing the efficiency of such crews and the equipment they are using, if the conditions under which they are working are known. In this way valuable data on the productivity of various types of chain saws, and of chain saws vs. bow or cross-cut saws can be accumulated. In each case, of course, enough of a sample should be accumulated to minimize the effect of purely temporary conditions, such as an infrequent breakdown of the equipment, unusually difficult working conditions, or a crew that is not working harmoniously.

If such records were regularly collected, we would soon see a tremendous improvement in the working methods and equipment used; and the over-all efficiency of methods currently used on northeastern logging operations could not help but be improved materially.

APPENDIX

SAMPLE CALCULATION OF COST PER HOUR[1/]

SPECIAL 6-CORD, 6-by-4, PULPWOOD TRUCK:

Cost, complete with pulpwood rack	$8,000
Tire replacement cost (charged against mileage)	1,000
Net investment	7,000
Average round trip	40 miles
Working day	7.0 hours
Working days per year	300 days
Depreciation period	5 years
Average fixed investment (60% of net investment)	$4,200

Fixed cost per hour

	Yearly	Daily	Hourly
Interest @ 6% on average fixed investment	$ 252.00	$ 0.84	$0.120
Depreciation (total net investment, 5 years)	1,400.00	4.67	.667
Insurance (estimated)	350.00	1.17	.167
License fees (average)	300.00	1.00	.143
Garage, storage, light, heat, water	300.00	1.00	.143
Repainting every 2 years	50.00	0.17	.024
Driver's wages @ $1.50 per hour	3,150.00	10.50	1.500
Total fixed charges whether traveling or not	$5,802,00	$19.35	$2.76

Total fixed cost per minute: $0.046.

Operating cost per hour

Tires, 5,000 hours @ $1,000 per set	$0.500
Chassis repair (excluding accidents)	.457
Body and equipment maintenance	.080
Lubrication, inspection, adjustment	.094
Fuel, 3.8 gallons per hour @ 20¢	.760
Engine oil, 1 quart every 5 hours @ 25¢	.050
Total operating cost per hour	$1.941
Total cost while traveling (fixed plus operating)	$4.70

1/ These cost figures are illustrative only. They were adapted from average cost figures provided by Mack-International Motor Truck Co. For any specific case the appropriate figures would have to be obtained and worked out as above.

SAMPLE CALCULATION OF COST PER HOUR[2/]

35-HP. DIESEL TRACTOR WITH WINCH AND DOZER BLADE:

Cost complete, delivered	$5,500
Depreciation period	5 years
Hours use per year	2,000 hours
Average fixed investment (60% of cost)	$3,300

Fixed cost per hour

	Yearly	Hourly
Interest @ 6% of average investment	$ 198.00	$0.099
Depreciation	1,100.00	.550
Taxes and insurance (4% of average investment)	132.00	.066
Driver's wages @ $1.50 per hour	3,000.00	1.500
	$4,430.00	$2.215

Operating cost per hour

Operating supplies--cutting edges, cables, etc.	$0.420
Fuel, 1.8 gallons per hour @ 9¢ (diesel)	.162
Lubrication	
Engine oil, 0.05 gal. per hr. @ 58¢ per gallon	.029
Transmission and final drive, 0.02 gal. per hour @ 53¢ per gal.	.011
Replaceable filter element	.005
Track roller grease, 0.01 lb. per hr. @ 11¢ per lb.	.001
Misc. grease, 0.05 lb. per hr. @ 10¢ per lb.	.005
Repairs and labor	.424
Total operating cost per hour	$1.057
Total cost while operating (fixed plus operating)	$3.272

2/ These costs are illustrative only. They were adapted from average cost figures provided by Allis-Chalmers Manufacturing Co For any specific case the appropriate figures would have to be obtained and worked out as above.

Table 3.--Average weight of green logs per 1,000 board feet[1] [2]
(International 1/4-inch rule)

Species	12-inch diameter	18-inch diameter	24-inch diameter
	Pounds	Pounds	Pounds
Ash, white	7,600	6,650	6,350
Aspen (popple)	7,400	--	--
Basswood	6,500	5,700	5,400
Beech	8,700	7,700	7,250
Birch, yellow	9,000	7,950	7,550
Cherry, black	7,200	6,300	6,000
Elm, white	7,700	6,850	6,450
Fir, balsam	7,100	6,250	5,900
Hemlock	7,700	6,750	6,400
Hickory	10,000	8,900	8,400
Locust, black	9,200	--	--
Maple, sugar	8,800	7,800	7,350
Maple, red	8,100	7,200	6,850
Oak, red	10,200	8,950	8,500
Oak, white	9,900	8,650	8,200
Pine, Norway (red)	6,650	5,900	5,400
Pine, pitch	8,500	7,550	7,150
Pine, white	6,200	5,450	5,100
Poplar, yellow (tulip)	6,000	5,300	5,000
Spruce, red	5,300	4,650	4,450
Sycamore	8,200	7,250	6,850
Walnut, black	8,150	7,200	6,850

1/ Excluding ice, mud, excess water, etc.

2/ Based on Forest Products Laboratory figures (as given in table 1 of U.S. Dept. Agr. Farmers' Bul. 1210), converted from Doyle log rule to International 1/4-inch rule for 12-foot logs.

Table 4.--Average weight of peeled green pulpwood per cord (128 stacked cubic feet)[1/] [2/]

Species	Weight green	Weight air-dry
	Pounds	Pounds
Ash, white	4,300	3,800
Aspen (popple)	3,900	2,300
Basswood	3,800	2,300
Beech	4,850	4,050
Birch, yellow	5,100	3,950
Birch, paper	4,500	3,400
Cedar, white	2,800	2,200
Fir, balsam	4,500	2,500
Hemlock, eastern	5,000	2,800
Maple, sugar	5,050	3,950
Maple, red	4,500	3,400
Oak, red	5,750	3,950
Oak, white	5,650	4,200
Pine, loblolly	5,300	3,600
Pine, pitch	5,400	3,500
Pine, red (Norway)	4,200	3,400
Pine, white	3,600	2,500
Poplar, yellow	3,400	2,500
Spruce, red	3,400	2,800
Sycamore	4,650	3,050
Tamarack	4,700	3,700

1/ Excluding ice, mud, excess water, etc.

2/ Based on U.S. Forest Products Laboratory figures (as given in table 6 of the U.S. Dept. Agr. Wood Handbook), converted from weight per cubic foot to weight per cord on the basis of 100 cubic feet per cord for softwoods and 90 cubic feet per cord for hardwoods.

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